

CLAIMS:

1.           A lithographic projection apparatus comprising:
  - a radiation system for providing a projection beam of radiation;
  - a support structure for supporting patterning means, the patterning means serving to pattern the projection beam according to a desired pattern;
  - a substrate table for holding a substrate;
  - a projection system for projecting the patterned beam onto a target portion of the substrate;
  - a liquid supply system for at least partly filling a space between the final element of said projection system and said substrate with liquid,
  - wherein said liquid supply system comprises bubble reduction means.
2.           A lithographic projection apparatus according to claim 1, wherein said bubble reduction means comprise bubble detection means.
3.           A lithographic projection apparatus according to claim 2, wherein said bubble detection means comprise at least one ultrasonic transducer, the attenuation of ultrasonic waves in said liquid being measured by said transducer so as to obtain information about bubbles present in said liquid.
4.           A lithographic projection apparatus according to claim 3 wherein said ultrasonic transducer measures ultrasonic attenuation as a function of frequency.
5.           A lithographic projection apparatus according to claim 1, wherein said bubble reduction means comprise bubble removal means.
6.           A lithographic projection apparatus according to claim 5, wherein said bubble removal means comprise a degassing device, said degassing device comprising an isolation chamber, wherein a space above liquid in said isolation chamber is maintained at a pressure

below atmospheric pressure encouraging previously dissolved gases to come out of solution and be pumped away.

7. A lithographic projection apparatus according to claim 5, wherein said bubble removal means provides a continuous flow of liquid over the final element of said projection system and said substrate to transport bubbles in said liquid out of said space between the final element of said projection system and said substrate.

8. A lithographic projection apparatus according to claim 1, wherein said bubble reduction means comprise a liquid pressurization device to pressurize said liquid above atmospheric pressure to minimize the size of bubbles and encourage bubble-forming gases to dissolve into said liquid.

9. A lithographic projection apparatus according to claim 1, wherein the composition of said liquid is chosen to have a lower surface tension than water.

10. A lithographic projection apparatus according to claim 1, wherein said bubble reduction means treat said liquid before it is supplied to said space between the final element of said projection system and said substrate.

11. A lithographic projection apparatus according to claim 10, wherein the treated liquid is kept in a sealed container, excess space in said sealed container being filled with one or more of the following: nitrogen gas, argon gas, helium gas or a vacuum.

12. A lithographic projection apparatus according to claim 3, wherein an ultrasonic transducer is arranged in a pulse-echo configuration, said transducer acting both to transmit ultrasonic waves and, after reflection, to receive ultrasonic waves that have been attenuated during propagation along a path through said liquid.

13. A lithographic projection apparatus according to claim 3, wherein said bubble detection means comprise two spatially separated ultrasonic transducers, the first arranged to transmit ultrasonic waves, and the second to receive ultrasonic waves that have been

attenuated during propagation along a path through said liquid between the two transducers.

14. A lithographic projection apparatus according to claim 5, wherein said bubble removal means includes two spatially separated ultrasonic transducers, arranged to produce ultrasonic standing-wave patterns within said liquid which trap bubbles within the nodal regions, said bubble removal means being arranged to displace said bubbles through the use of phase-adjusting means linked with said transducers, said phase-adjusting means causing spatial shift of nodal regions and bubbles trapped therein.

15. A lithographic projection apparatus according to claim 5, wherein said bubble removal means comprises an electric field generator for applying an electric field to said liquid, said electric field being capable of dislodging bubbles attached to said substrate.

16. A lithographic projection apparatus according to claim 5, wherein said bubble removal means comprises a selective heater for selectively controlling the temperature and therefore size of bubbles of a particular composition.

17. A lithographic projection apparatus according to claim 16, wherein said selective heater comprises a microwave source.

18. A lithographic projection apparatus according to claim 5, wherein said bubble removal means comprises a particle input device for introducing particles into said liquid, and a particle removal device for removing said particles from said liquid.

19. A lithographic projection apparatus according to claim 18, wherein said particles comprise a surface with characteristics that encourage bubbles to attach thereto.

20. A lithographic projection apparatus according to claim 2, wherein said bubble detection means comprises a light source, a light detector and a light comparator, said light source and said light detector being arranged so that light emitted by said source propagates between said source and said detector through a portion of said liquid, said comparator

being arranged to detect changes in the proportion of said emitted light that arrives at said detector after propagation through a portion of said liquid.

21. A lithographic projection apparatus comprising:

- a radiation system for providing a projection beam of radiation;
- a support structure for supporting patterning means, the patterning means serving to pattern the projection beam according to a desired pattern;
- a substrate table for holding a substrate;
- a projection system for projecting the patterned beam onto a target portion of the substrate;
- a liquid supply system for at least partly filling a space between the final element of said projection system and said substrate with liquid; and
- a detection system for detecting impurities in said liquid, including a light source, a light detector and a light comparator, said light source and said light detector being arranged so that light emitted by said source propagates between said source and said detector through a portion of said liquid, said comparator being arranged to detect changes in the proportion of said emitted light that arrives at said detector after propagation through a portion of said liquid.

22. A lithographic projection apparatus according to claim 21, wherein said detection system is arranged to detect particles in said liquid between said final element of the projection system and said substrate.

23. A device manufacturing method comprising:

- providing a substrate that is at least partially covered by a layer of radiation-sensitive material;
- providing a projection beam of radiation using a radiation system;
- using patterning means to endow the projection beam with a pattern in its cross-section;
- projecting the patterned beam of radiation onto a target portion of the layer of radiation-sensitive material;

providing a liquid supply system for at least partly filling a space between the final element of said projection system and said substrate with liquid; and  
reducing bubbles in said liquid supply system.

24. A lithographic projection apparatus comprising:
- a radiation system for providing a projection beam of radiation;
  - a support structure for supporting patterning means, the patterning means serving to pattern the projection beam according to a desired pattern;
  - a substrate table for holding a substrate;
  - a projection system for projecting the patterned beam onto a target portion of the substrate;
  - a liquid supply system for at least partly filling a space between the final element of said projection system and said substrate with liquid; and
  - a liquid quality monitor capable of switching the operational state of the projection apparatus between an active state and a suspended state, said active state being selected when the liquid quality is determined to be above a predefined threshold and said suspended state being selected when the liquid quality is determined to be below a predefined threshold state.